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(74) Agents: WOOD, J., Ray et al.; Motorola Inc., Intellectual Property Dept., 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

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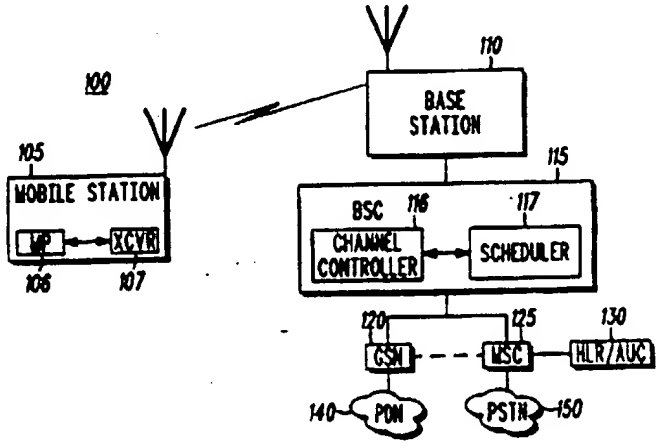
(54) Title: METHOD FOR COMMUNICATING DATA IN A WIRELESS COMMUNICATION SYSTEM



(57) Abstract

The disclosed system is capable of allocating plural subchannels based on user data priority. In one embodiment, a subscriber determines the throughput it would like and fragments a data packet in that number of service data units, and requests that number of subchannel allocations from a serving base station. Upon receipt of the access request(s), including any priority indicators, the system determines from the access request(s) whether to allocate the subchannel(s) to the subscriber. Further access requests are received periodically and scheduled, and when a higher priority message is received, completion of a lower priority message is deferred and the higher priority request allocated. Thus, an improved access procedure is provided accommodating varying throughput rates with a more robust transfer because of the packet fragmentation and multiple-subchannel transfer.

METHOD FOR COMMUNICATING DATA IN A WIRELESS COMMUNICATION SYSTEM

FIELD OF THE INVENTION

The present invention relates to communications and more particularly an improved method for communicating data in a wireless communications system.

BACKGROUND

The last 10 years has seen a tremendous increase in the demand for wireless networks capable of handling data communications. Unlike voice services, such as the GSM (Global System for Mobiles) cellular service, in which circuit-switched communications are used because of the sensitivity of users to the timing of oral dialogue, greater efficiencies can be achieved in data communications through the use of packet-switched and hybrid communications. Thus, it is anticipated that a significantly increased throughput can be achieved for shorter traffic by using proposed services such as the GPRS (GSM Packet Radio Service) over traditional circuit-switched wireless technology.

However, with the increased demand for wireless services has also come a demand for higher throughput rates of data traffic, at least for some users. One proposed solution to this need is the use of "quality of service" (QOS) grades for data traffic. By designating a particular data message with a high QOS grade or priority, users who have the need for rapid end-to-end delivery of their data will have their data delivered ahead of lower QOS data. On the other hand, users who do not want to pay the higher QOS rates and can tolerate longer end-

The second problem, limited throughput, is particularly noticeable in TDMA systems. For example, in current GSM systems the maximum throughput for packet data is 9.6 kbps with error correction, or higher without, because only about 33 kbps raw transmission rate is possible for a burst given the standardized bit rate of 270.833 kbps and .577 ms (millisecond) for each of the eight time-slot periods. To improve this throughput, one proposal has been to allow for the use of multiple subchannels (e.g., 2 or more time slots per frame), thus effectively doubling or more the throughput rate. A drawback to this approach is that environmental factors such as fading often last longer than a single time slot, although most fades in moving subscribers will be over within a frame period. Under the prior approach, a given fade only stands to corrupt a single time slot period of data, while under the proposed approach a fade may corrupt 2 or more time-slot periods of data in a row. This in turn increases the likelihood that any error correction coding will be unable to successfully recover the received packet, thus leading to an increase in ARQs (automatic repeat requests) and overall decrease in the throughput rate.

There remains therefore a need for an improved means for data communications in wireless systems that solves these and related problems.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a wireless communications system according to first and second embodiments of the invention;

These problems and others are solved by the improved method and apparatus according to the invention. A presently preferred embodiment of the invention is a system for allocating one or more subchannels based on priority of user data. After receiving a control message including a current priority service level message from a base station, a subscriber unit determines whether or not to send an access request for one or more subchannels. Upon receipt of an allocation/access request, the system infrastructure determines from the access request whether to allocate the subchannel(s) to the subscriber unit. Periodically further access requests are received and scheduled and, when a higher priority message is received, completion of a lower priority message is deferred and the higher priority request allowed to proceed. Thus, an improved access procedure is provided that allows for quicker access times as the priority of the data traffic increases. In a further embodiment, plural subchannels are requested and, when allocated, a data packet is fragmented into plural data units and each data unit sent via a different subchannel. Because the effect of the fragmenting and transmission on different subchannels is similar to that of interleaving the original data packet, a more robust and higher throughput can be achieved with the present invention.

Turning now to FIG. 1, there is generally depicted a wireless communications system 100 having one or more subscriber units (i.e., mobile station (MS) 105) communicating via a base station (BS) 110 and base station controller (BSC) 115. The subscriber unit may be of such diverse types as dedicated data units (e.g., personal digital assistants (PDAs)), radiotelephones adapted for coupling with data terminals (e.g., portable computers), or wireless adapter devices (e.g., wireless modems adapted for coupling with computers,

bandwidth, another approach proposed is that of assigning plural time slots and sequentially transmitting the PDUs. Thus, for example, if time slots 1 and 2 were assigned, PDU "A" would be sent in time slot 1 of frame 1, PDU "B" in time slot 2 of frame 1, PDU "C" in time slot 1 of frame 2, and so on. The present embodiment improves on these approaches by further segmenting the packet 205 into plural SDUs (service data units, e.g., 211, 212 and 213), each SDU for transmission in a designated subchannel (as further shown by FIG. 3, where the PDUs being sent in time slot 2 of channel 305 make up a MAC layer subchannel SDU 310). Thus, the actual transmission sequence 220 in the illustrated case is SDU 211 in time slot 1, SDU 212 in time slot 2, and SDU 213 in time slot 3. In doing so, the PDUs are effectively interleaved, thus providing for greater immunity to fading while permitting increased throughput via multiple subchannels. Upon reception, the plural PDUs is defragmented and error corrected into a replica of the original data packet.

In a preferred approach to fragmenting the data packet, the requesting communication unit begins by determining the desired throughput rate (i.e., how many subchannels it wants to request) and fragments the packet 205 accordingly. This allows the subscriber to include, overhead permitting, the size of each SDU in the access request.

For simplified operations, an access request is sent on each desired subchannel. For example, where the base station broadcast information indicates that time slots 1-3 of a communications resource/channel are available for GPRS service, a subscriber wanting high throughput would fragment its data packet into 3 SDUs and send an access request on all three time slots. When received by the infrastructure, e.g., at scheduler 117 of BSC 115, a determination is made on whether

multiframe channel structure is shown which may be used in implementing this feature. A GSM control channel multiframe 405 has 51 frames including BCCH (broadcast control channel) frames 409 and CCCH (common control channel) frames 408, FCCH (frequency control channel) frames 406 and SCH (synchronization channel) frames 407. A GPRS multiframe does not need to repeat the SCH and FCCH frames, so in the preferred embodiment of the invention these are replaced by control UBGs (uplink burst groups) for the uplink channel 410, control DBGs (downlink burst groups) for the downlink channel 420, and traffic burst groups. In the preferred approach for GPRS a MAC layer codeword (e.g., an error correction encoded packet data unit (PDU) of the original data packet) is additionally defined as a four frame burst group (i.e., it occupies 4 time slots, in which case the MAC layer PDU is typically the same as the burst group). Thus, time-synchronized and time division multiplexed uplink and downlink communications channels having repeating control and traffic communications periods are provided.

In this case, a typical messaging sequence 610 for an uplink data transfer would proceed as follows. Based on broadcast priority service parameters, the subscriber determines when to begin by sending a random access burst 505. Because a typical random access burst is limited in size, at best a limited priority indicator between two levels of service is possible during this initial access period (e.g., either distinguishing between highest priority data and all others, or between all priority data and "best efforts" data, depending on system design). Further information, such as a full priority indicator (i.e., indicating the specific grade of service requested) is thus typically needed in a supplementary access period. In this case, an allocation 507 of a single

first portion) until after the second user's data is sent. If the second user's data only consists of three codewords, scheduler 117 can allocate the next three traffic UBGs to the second user, and reallocate the subsequent traffic UBGs to the first user to finish sending a further portion of its data packet. One skilled in the art will recognize that this multiframe structure can be readily altered based upon the design factors for any given system. What is significant for this particular embodiment is that allocations are made only for a limited portion of the resource (e.g., a limited period of time such as a maximum number of burst groups), following which another allocation is made--either for the same data, or a new, higher priority data packet.

Turning to FIG. 7 and 8, the access control and data transfer functions of the preferred embodiment are further illustrated. In FIG. 7, the control/traffic communications flow among the MS 710, BS subsystem 720 and GSN 730 is generally depicted. Both MS 710 and BS/BSC 720 include access controllers (712 and 722 respectively) and data transmission controllers (714 and 724 respectively), which GSN 730 includes an access manager 732. Current configuration parameters, including loading and service priority information derived from usage and access channel statistics, is communicated between the GSN 730 and BS/BSC access controller 722. Based on this information access control parameters are determined and broadcast via the BS to MSs in the BS service area. These access parameters are preferably the current service priority level and access probability parameters. When the MS data transmission controller 714 receives a data transfer request, a transmission request message is transferred to the access controller 712 (i.e., moving from state 810 to monitor state 820 of FIG. 8). Based on the access control parameters and its data message

control parameters. Preferably these parameters include a vector of access probability values $\{p_1, p_2, .. p_n\}$, each p value representing a p-persistence value corresponding to grade of service/priority levels 1 through n. The table of FIG. 10 illustrates one possible set of p-persistence values p_n. In this case, data having a priority level 1 has a p vector value of .05. Various means for broadcasting and applying the p_n values may be used, with one such being as follows. In order to facilitate transmission of the p_n values the closest integer $1/p_n$ ($=w_n$, or an access window period) is transmitted for each value in the vector. Upon selecting the value w_n corresponding to the priority level of the data, an MS generates a random number between 1 and w_n for an access delay value, and counts this value/number of allowed burst periods (i.e., data time slots available for access bursts) before transmitting its access/reservation request; counting is suspended during periods when the MS is not allowed access. Thus, as illustrated in FIG. 9, a priority level 1 packet will have a maximum wait period t_1 (901) substantially shorter than periods t_2 through t_4 (902-904) for priority levels 2 through 4. However, the actual burst period 905 at which an access request is sent could be the same for data traffic of all priority levels (at least those greater than the minimum priority level), although with differing probabilities of occurrence.

While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alterations, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. For example, while processor 106, channel controller 116 and scheduler 117, and other circuits, are described in terms of specific logical/functional circuitry relationships, one skilled in the art will appreciate that such may be implemented in a

CLAIMS

1 . A method of communicating plural data units via a wireless communications system, comprising:

fragmenting a data packet into plural data units;

requesting plural subchannels of a communications resource for communicating the plural data units;

receiving an allocation of at least one designated subchannel; and

communicating the plural data units each via one of the at least one designated subchannels.

2. The method of claim 1, wherein the step of receiving comprises receiving a first allocation of the at least one designated subchannel for a first period of time, and receiving subsequent allocations of the at least one designated subchannel for subsequent periods of time until all the plural data units have been communicated.

3. The method of claim 1, wherein the step of receiving comprises receiving an allocation of first and second designated subchannels for a first period of time, the method further comprising:

encoding each of the plural data units into plural packet data units (PDUs);

following the step of receiving the allocation of the first and second designated subchannels, communicating during the first period of time a first PDU of a first one of the plural data units via the first designated subchannel and a first PDU of a second one of the plural data units via the second designated subchannel; receiving further allocations of the first and second designated subchannels for further periods of time and communicating each remaining PDU of the first and second

requesting plural subchannels of a communications resource for communicating a data packet;

receiving an allocation of n designated subchannels, where n is a number greater than 1;

fragmenting the data packet into n data units; and communicating each of the n data units via a respective one of the n designated subchannels.

8. The method of claim 7, wherein the step of requesting includes transmitting a first access request in a first time slot, and sending a supplementary access request in a second time slot including a first parameter indicating a capability for multiple sub-channel transmission.

9. The method of claim 7, wherein the step of communicating includes communicating each of the n data units asynchronously with respect to each other.

10. The method of claim 9, wherein the step of receiving comprises receiving an allocation of first and second designated subchannels for a first period of time, the method further comprising:

encoding each of the plural data units into plural packet data units (PDUs);

following the step of receiving the allocation of the first and second designated subchannels, communicating during the first period of time a first PDU of a first one of the plural data units via the first designated subchannel and a first PDU of a second one of the plural data units via the second designated subchannel; receiving a second allocation of the first designated subchannel for a second period of time and communicating a second PDU of the first one of the plural data units during the second period of time; and

communications period from a second communication unit;

deferring allocation to the first requesting communications unit of at least one subchannel of the first channel and allocating said at least one subchannel to the second communication unit;

after receiving a data packet from the second communication unit via said at least one subchannel, transmitting a further allocation of said at least one subchannel for a further traffic communications period to the first requesting communications unit, and receiving a second portion of the data packet from the first requesting communication unit during the further traffic communications period in response to the transmitted further allocation.

13. A method of communicating plural data units via a wireless communications system, comprising:

receiving a request from a first communication unit for allocation of plural subchannels of a communications resource for communication of a data packet;

allocating, when the plural subchannels are available for allocation, the plural subchannels to the first communication unit; and

receiving plural data units each via one of the plural subchannels and defragmenting the plural data units into the data packet.

14. The method of claim 13, wherein the step of receiving a request comprises receiving a request from the first communication unit for allocation on each of the plural subchannels, the step of allocating comprises allocating each of the plural subchannels asynchronously with respect to each other of the plural subchannels as said each of the plural subchannels is available and until a complete one of the plural data units is received via said each of the plural subchannels.

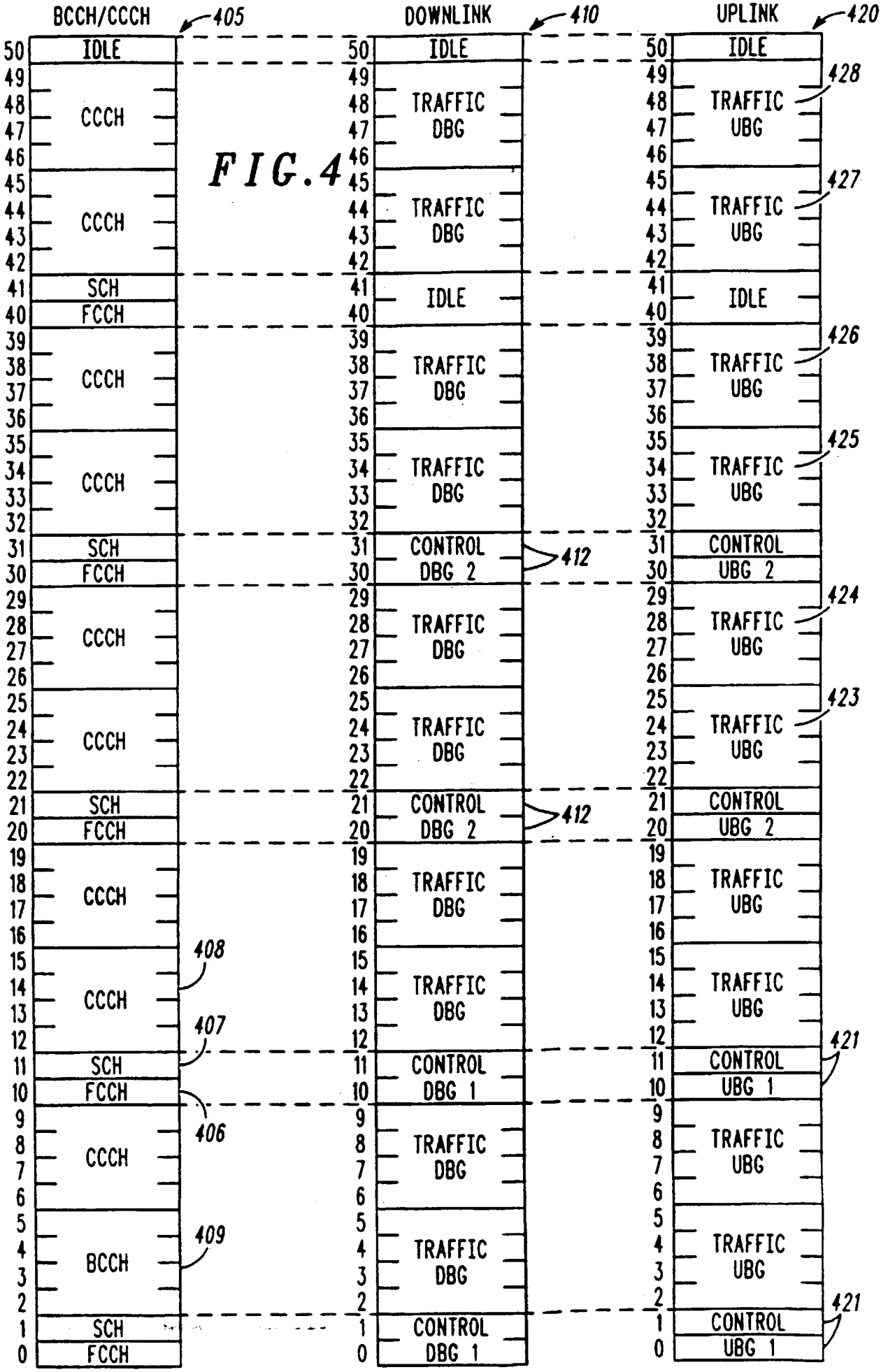

BCCH/CCCH
405
DOWNLINK
410
UPLINK
420
IDLE
CCCH
SCH
FCCH
BCCH
TRAFFIC DBG
CONTROL DBG 2
CONTROL DBG 1
TRAFFIC UBG
CONTROL UBG 2
CONTROL UBG 1
412
421
423
424
425
426
427
428
406
407
408
409

FIG. 4

FIG.6

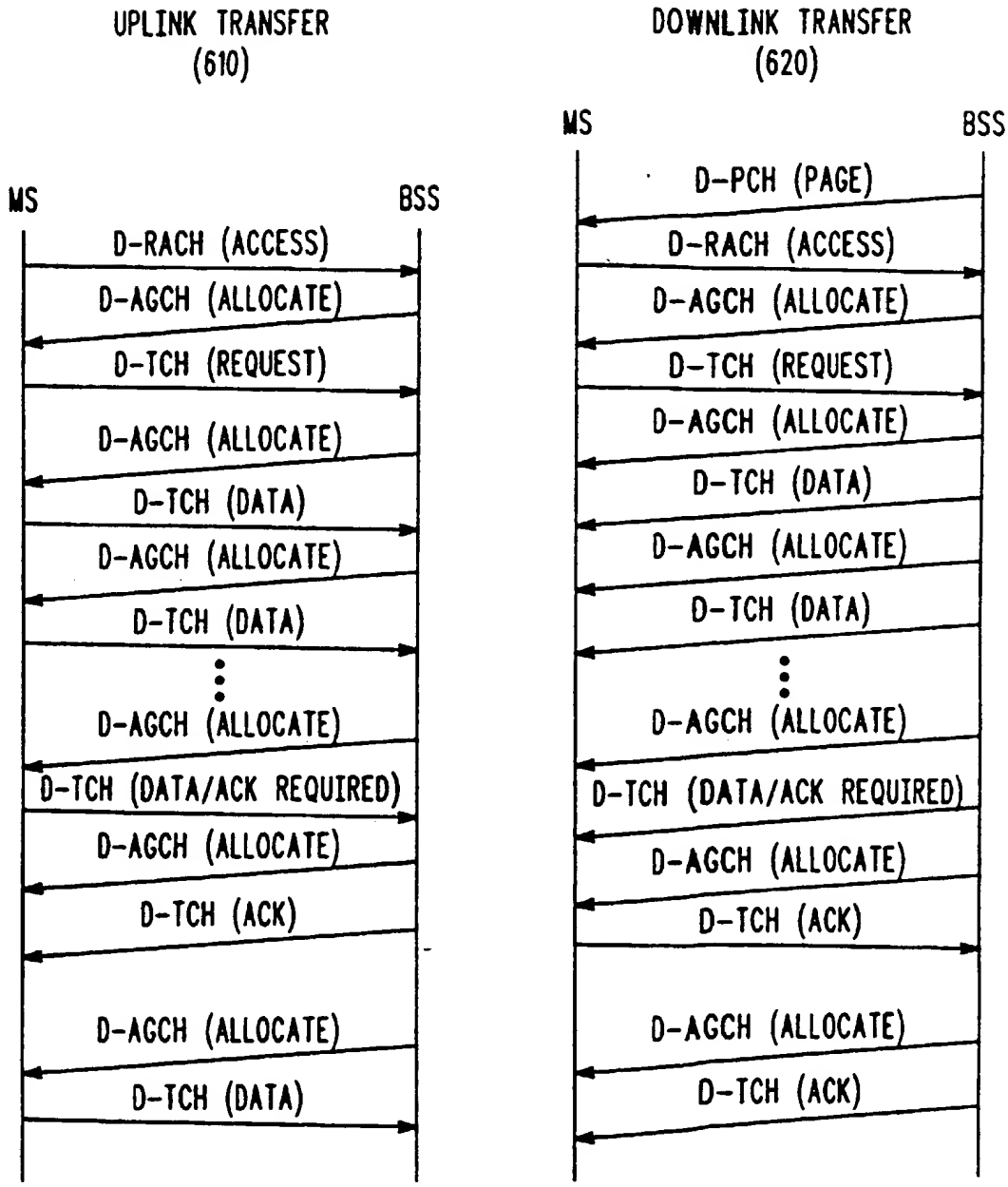

UPLINK TRANSFER
(610)
MS
BSS
D-RACH (ACCESS)
D-AGCH (ALLOCATE)
D-TCH (REQUEST)
D-AGCH (ALLOCATE)
D-TCH (DATA)
D-AGCH (ALLOCATE)
D-TCH (DATA)
D-AGCH (ALLOCATE)
D-TCH (DATA/ACK REQUIRED)
D-AGCH (ALLOCATE)
D-TCH (ACK)
D-AGCH (ALLOCATE)
D-TCH (DATA)
DOWNLINK TRANSFER
(620)
MS
BSS
D-PCH (PAGE)
D-RACH (ACCESS)
D-AGCH (ALLOCATE)
D-TCH (REQUEST)
D-AGCH (ALLOCATE)
D-TCH (DATA)
D-AGCH (ALLOCATE)
D-TCH (DATA)
D-AGCH (ALLOCATE)
D-TCH (DATA/ACK REQUIRED)
D-AGCH (ALLOCATE)
D-TCH (ACK)
D-AGCH (ALLOCATE)
D-TCH (ACK)

FIG.8

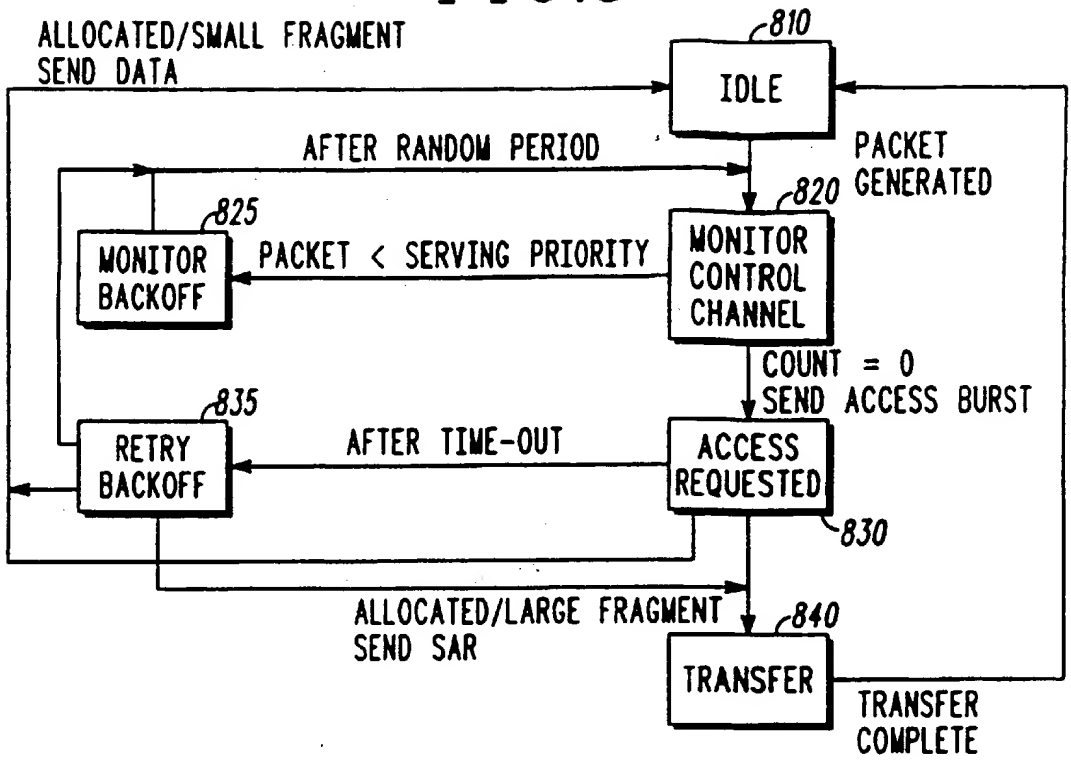
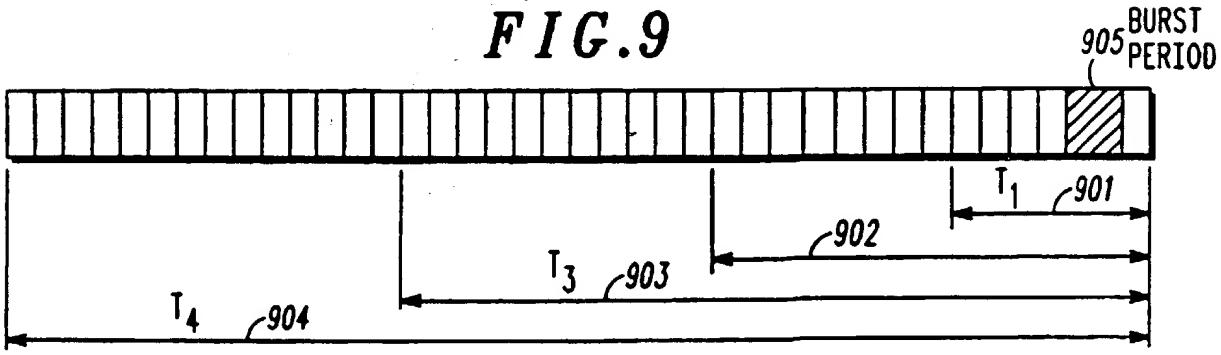


FIG.9



T_1: PRIORITY 1 ACCESS REQUEST PERIOD
T_2: PRIORITY 2 ACCESS REQUEST PERIOD
T_3: PRIORITY 3 ACCESS REQUEST PERIOD
T_4: PRIORITY 4 ACCESS REQUEST PERIOD

FIG.10

PRIORITY (n)	Pn	W_a=1/Pn
1	.05	20
2	.03	33
3	.025	40
4	.02	50

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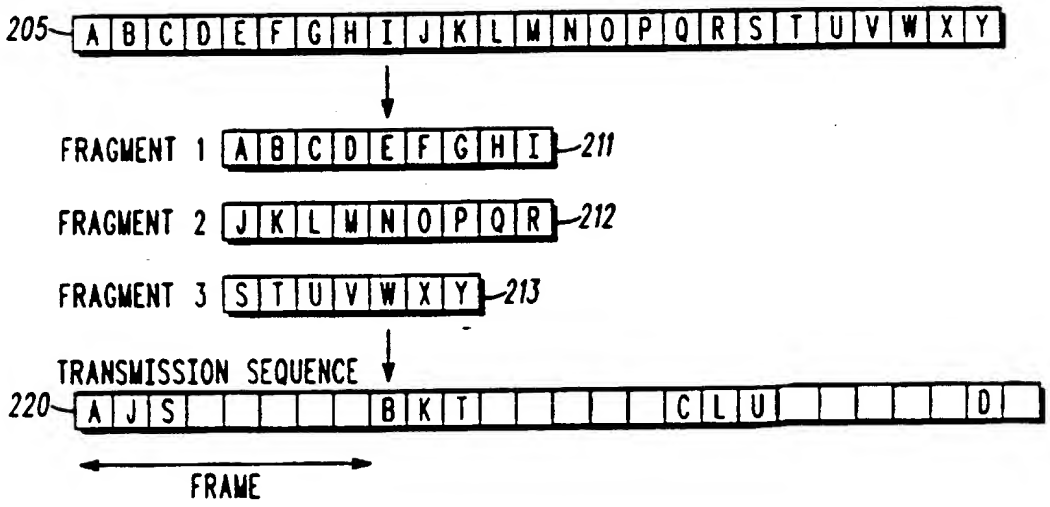
(54) Title: WIRELESS PACKET FRAGMENTATION AND MULTIPLE SUBCHANNEL TRANSFER



(57) Abstract

The disclosed system is capable of allocating plural subchannels based on user data priority. In one embodiment, a subscriber determines the throughput it would like and fragments a data packet (205) in that number of service data units (211, 212, 213), and requests that number of subchannel allocations from a serving base station. Upon receipt of the access request(s), including any priority indicators, the system determines from the access request(s) whether to allocate the subchannel(s) to the subscriber. Further access requests are received periodically and scheduled, and when a higher priority message is received, completion of a lower priority message is deferred and the higher priority request allocated. Thus, an improved access procedure is provided accommodating varying throughput rates with a more robust transfer because of the packet fragmentation and multiple-subchannel transfer.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/14038

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04J 3/16; H04Q 7/22
US CL :370/337, 348, 444, 474
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/319, 321, 322, 326, 329, 336, 337, 347, 348, 349, 439, 442, 443, 444, 461, 468, 474, 913

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,440,545 (BUCHHOLZ et al.) 08 August 1995, col. 1, lines 37-47.	1,2,6-8,13
Y,E	US 5,583,869 (GRUBE et al.) 10 December 1996, entire document.	1,2,6-8,13
A	US 4,745,599 (RAYCHAUDHURI) 17 May 1988, entire document.	1-14
A	US 5,260,989 (JENNESS et al.) 09 November 1993, entire document.	1-14
A	US 5,161,194 (UJIIE) 03 November 1992, entire document.	1-14

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

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Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MATTHEW C. PHILLIPS Telephone No. (703) 305-4959